# Chapter C4: Value of Baseline I&E Losses from Selected Facilities on the Ohio River

This chapter presents the results of EPA's evaluation using benefits transfer techniques of the economic losses that are associated I&E at Ohio River facilities. First, summed results for the nine case study facilities with I&E data are presented. Then, the extrapolation of these results to other Ohio River CWIS is discussed. Section C4-1 provides an overview of the valuation approach, Section C4-2 discusses losses to recreational fisheries, Section C4-3 discusses the value of forage losses, Section C4-4 discusses nonuse values, Section C4-5 summarizes the economic valuation of losses at the nine case study facilities, and Section C4-6 discusses the extrapolation of these values to other Ohio River CWIS.

CHAPTER CONTENTS



## C4-1 Overview of Valuation Approach

I&E at Ohio River CWIS affect recreational fisheries as well as forage species that contribute to the biomass of fishery species. There are no commercial fisheries located in the study area.

EPA evaluated both fishery and forage species losses to capture the total economic value of I&E losses at Ohio River CWIS. Recreational fishery impacts were based on benefits transfer methods, applying results from nonmarket valuation studies. The economic value of forage species losses was estimated by two methods, (1) the replacement cost of stocking hatchery fish to replace fish impinged and entrained, or (2) the foregone production of commercial and recreational species that use the forage species as a prey base. All of these methods are explained in further detail in Chapters A5 and A9 of this document.

As discussed in Chapters A5 of Part A, the yield estimates presented in Chapter C3 are expressed as total pounds. Because the economic evaluation of recreational yield is based on numbers of fish rather than pounds, foregone recreational yield was therefore converted to numbers of fish. This conversion was based on the average weight of harvestable fish of each species. Note that the numbers of foregone recreational fish harvested are typically lower than the numbers of age 1 equivalent losses, since the age of harvest of most fish is greater than age 1.

# C4-2 Economic Value of Average Annual Losses to Recreational Fisheries Resulting from I&E at Nine Facilities on the Ohio River

## C4-2.1 Economic Values for Recreational Losses from the Consumer Surplus Literature

There is a large literature that provides willingness-to-pay (WTP) values for increases in recreational catch rates. These increases in value are benefits to the anglers, and are often referred to by economists as "consumer surplus" per additional fish caught.

When using values from the existing literature as proxies for the value of a trip or fish at a site not studied, it is important to select values for similar areas and species. Table C4-1 gives a summary of several studies that are closest to the Ohio River fishery in geographic area and relevant species.

**Table C4-1: Selected Valuation Studies for Estimating Changes in Catch Rates for Species in the Ohio River**

| Authors | Study Location and Year | Item Valued | Value Estimate ($2000) |
|---|---|---|---|
| Milliman et al. (1992) | Green Bay, 1986 | Recreation and commercial net benefits from proposed perch rehabilitation programs | Yellow perch $0.31 |
| Samples and Bishop (1985) | Lake Michigan, 1978 | Catch rate improvement of 1 percent | Lake Michigan trout/salmon $16.01 |
| Boyle et al. (1998) | United States, 1996 | WTP (increased costs) to get someone to stop bass or trout fishing | Other bass $1.58 - $3.95<br>Rainbow trout $3.25 -$3.71 |
| Cahrbaneau and Hay (1978) | Mississippi Flyway (Central U.S.), 1978 | WTP (increased costs) to get someone to stop doing his/her favorite and second-favorite hunting or fishing activities | Catfish $2.64<br>Pumpkinseed, Sunfish, Perch, Crappie, Bluegill, Paddlefish, Muskellunge, Panfish $1.00<br>Walleye $7.92 |
| Sorg et al. (1985) | Central Idaho, 1982 | Doubling the catch rate per trip | Catfish, Crappie, Walleye Northern Pike, Grass pickerel, Sauger, Paddlefish, Muskellunge, Warmwater fish $5.02 |
| Norton et al. (1983) | Mid-Atlantic coast, 1979-1980 | Catch rate increase of 1 striped bass per trip | Striped bass $11.08 - $15.55 |

Norton et al. (1983) estimated the value of the striped bass fishery for the mid-Atlantic coast, including Delaware and New Jersey. The value of the recreational fishery was estimated using a travel cost method (TCM) and data from the 1979 NMFS survey. The value of the commercial fishery was calculated by valuing the catch using catch data and prices from 1980.

Sorg et al. (1985) developed estimates of the willingness to pay for a fishing trip under the existing conditions among licensed Idaho steelhead anglers, using data gathered in 1982. Mean willingness to pay was estimated using data from an iterative bidding contingent valuation (CV) survey, resulting in a value of $31.45, and from a TCM, where the results range from $19.89 to $27.87. In addition, the CVM portion of the study developed mean estimates of the marginal willingness to pay for a doubling in the number of fish caught per trip, with a value of $9.91, and for a 50 percent increase in the size of the fish caught over current conditions, with a value of $7.69 (all values in $1982).

Cahrbaneau and Hay (1978) estimated the value of panfish, catfish, and walleye by sampling a large group of sportsmen to see what increased costs would force a respondent to stop his/her favorite and second-favorite hunting and fishing activities.

Boyle et al. (1998) used the 1996 National Survey of Fishing, Hunting and Wildlife-Associated Recreation to estimate the value of bass and rainbow trout across the country. Respondents were asked a contingent valuation question that determined the regional values of these two species.

Samples and Bishop (1985) estimated the impact of increased success rates at various sites in Lake Michigan and the annual value of the alternative fishing sites. After modeling the demand for each of the 11 study sites and estimating the annual value for each site they developed a model to explain the variation in the annual site values that accounted for site and quality characteristics. The results of this model were used to develop an estimate that the value of an additional fish landed (associated with a 1 percent improvement in the success rate) would have an average value across the sites of $6.75 ($1978).

Milliman et al. (1992) estimated the value of yellow perch in Green Bay by calculating the net benefits derived from implementing various perch rehabilitation programs.

Since none of the studies consider the Ohio River directly, EPA used these estimates to create a range of possible consumer surplus values for the increases in recreational landings expected to result by reducing I&E at Ohio River facilities.

To estimate a unit value for recreational landings, EPA established a lower and upper value for the recreational species, based on values reported in studies in Table C4-1. Because the studies in Table C4-1 are geographically specific, EPA created a lower and upper value.

## C4-2.2 Economic Values of Recreational Fishery Losses Resulting from I&E at Nine Ohio River Case Study Facilities

Recreational losses are displayed in Tables C4-2 and C4-3 for I&E, respectively. Total losses to the recreational fisheries from I&E at the nine Ohio River case study facilities are estimated to range from $12,500 to $27,300 per year for impingement, and from $111,200 to $212,500 per year for entrainment. Results for individual facilities are presented in Appendix C3.

**Table C4-2: Average Annual Impingement of Recreational Fishery Species at Nine Ohio River Case Study Facilities and Associated Economic Values**

| Species | Loss to Recreational Catch from Impingement (# of fish) | Recreational Value/Fish | | Loss in Recreational Value from Impingement | |
|---|---|---|---|---|---|
| | | Low | High | Low | High |
| Black crappie | 452 | $1.00 | $5.02 | $452 | $2,271 |
| Bluegill | 47 | $0.31 | $1.00 | $15 | $47 |
| Channel catfish | 1,805 | $2.64 | $5.02 | $4,764 | $9,060 |
| Longear sunfish | 9 | $0.31 | $1.00 | $3 | $9 |
| Paddlefish | 54 | $1.00 | $5.02 | $54 | $269 |
| Sauger | 429 | $5.02 | $7.92 | $2,154 | $3,398 |
| Smallmouth bass | 165 | $1.58 | $3.95 | $261 | $651 |
| Striped bass | 21 | $11.08 | $15.55 | $231 | $325 |
| Sunfish spp. | 37 | $0.31 | $1.00 | $12 | $37 |
| Walleye | 21 | $5.02 | $7.92 | $105 | $166 |
| White bass | 2,791 | $1.58 | $3.95 | $4,410 | $11,026 |
| Total | 5,832 | | | $12,461 | $27,259 |

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**Table C4-3: Average Annual Entrainment of Recreational Fishery Species at Nine Ohio River Case Study Facilities and Associated Economic Values**

| Species | Loss to Recreational Catch from Entrainment (# of fish) | Recreational Value/Fish | | Loss in Recreational Value from Entrainment | |
|---|---|---|---|---|---|
| | | Low | High | Low | High |
| Black crappie | 1,284 | $1.00 | $5.02 | $1,284 | $6,447 |
| Bluegill | 1 | $0.31 | $1.00 | $0 | $1 |
| Channel catfish | 2,648 | $2.64 | $5.02 | $6,991 | $13,294 |
| Longear sunfish | 3,938 | $0.31 | $1.00 | $1,221 | $3,938 |
| Paddlefish | 16 | $1.00 | $5.02 | $16 | $78 |
| Sauger | 1,638 | $5.02 | $7.92 | $8,223 | $12,973 |
| Smallmouth bass | 16,170 | $1.58 | $3.95 | $25,548 | $63,870 |
| Sunfish spp. | 3,663 | $0.31 | $1.00 | $1,135 | $3,663 |
| Walleye | 12,666 | $5.02 | $7.92 | $63,581 | $100,311 |
| White bass | 2,014 | $1.58 | $3.95 | $3,182 | $7,956 |
| Yellow perch | 1 | $0.31 | $1.00 | $0 | $1 |
| Total | 44,038 | | | $111,182 | $212,532 |

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## C4-3 Economic Value of Forage Fish Losses

Many species affected by I&E are not commercially or recreationally fished. For the purposes in this study, EPA refers to all of these species as forage fish. Forage fish include species that are prey for other species and are important components of aquatic food webs. The following sections discuss the economic valuation of these losses using two alternative valuation methods.

### C4-3.1 Replacement Cost of Fish

The replacement value of fish can be used in several cases. First, if a fish kill of a fishery species is mitigated by stocking of hatchery fish, then losses to the commercial and recreational fisheries would be reduced, but fish replacement costs would still be incurred and should be accounted for. Second, if the fish are not caught in the commercial or recreational fishery, but are important as forage or bait, the replacement value can be used as a lower bound estimate of their value (it is a lower bound because it would not consider how reduction in their stock may affect other species' stocks). Third, where there are not enough use data to value losses to the recreational and commercial fisheries, replacement cost can be used as a proxy for lost fishery values. Typically the consumer or producer surplus is greater than fish replacement costs.

The cost of replacing forage fish lost to I&E has two main components. The first component is the cost of raising the replacement fish. Table C4-4 displays replacement costs for Ohio River species impinged and entrained based on values in the American Fisheries Society's *Sourcebook for the Investigation and Valuation of Fish Kills* (AFS, 1993). Totals for the nine case study facilities are $394,400 per year for impingement and $437,100 per year for entrainment. The costs listed are average costs to fish hatcheries across North America to produce different species of fish for stocking. The second component of replacement cost is the transportation cost, which includes costs associated with vehicles, personnel, fuel, water, chemicals, containers, and nets. AFS (1993) estimates these costs at approximately $1.13 per mile, but does not indicate how many fish (or how many pounds of fish) are transported for this price. Lacking relevant data, EPA did not include the transportation costs in this valuation approach.

**Table C4-4: Replacement Cost of Forage Species Impinged and Entrained at the Nine Ohio River Case Study Facilities[a]**

| Species | Hatchery Costs ($/lb) | Annual Cost of Replacing Forage Losses ($2000)[a] | |
|---|---|---|---|
| | | Impingement | Entrainment |
| Bigmouth buffalo | $0.42 | $998 | $0 |
| Black bullhead | $1.04 | $1 | $0 |
| Bluntnose minnow | $2.21 | $58 | $83,996 |
| Brown bullhead | $1.04 | $149 | $1,147 |
| Common carp | $0.20 | $469 | $143,464 |
| Darter spp. | $2.84 | $9 | $528 |
| Emerald shiner | $0.91 | $2,877 | $42,834 |
| Freshwater drum | $0.39 | $4,826 | $981 |
| Gizzard shad | $0.34 | $364,631 | $15,159 |
| Golden redhorse | $2.12 | $299 | $205 |
| Herring spp. | $0.52 | $0 | $86 |
| Logperch | $1.05 | $7 | $193 |
| Minnow spp. | $2.21 | $0 | $2,427 |
| Perch spp. | $1.05 | $0 | $97 |
| River carpsucker | $0.19 | $58 | $33,091 |
| Skipjack herring | $0.34 | $19,633 | $813 |
| Sucker spp. | $2.12 | $380 | $112,040 |
| Total | | $394,396 | $437,061 |

[a] Values are from AFS (1993). These values were inflated to $2000 from $1989, but this could be imprecise for current fish rearing and stocking costs.
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## C4-3.2 Production Foregone Value of Forage Fish

This approach considers the foregone production of commercial and recreational fishery species resulting from I&E of forage species based on estimates of trophic transfer efficiency, as discussed in Chapter A5 of Part A of this document. The economic valuation of forage losses is based on the dollar value of the foregone fishery yield resulting from these losses. Values for the nine case study facilities are from $8,700 to $19,900 per year for impingement (Table C4-5) and from $313,300 to $685,500 per year for entrainment (Table C4-6).

**Table C4-5: Mean Annual Value of Production Foregone of Selected Fishery Species Resulting from Impingement of Forage Species at Nine Ohio River Case Study Facilities**

| Species | Annual Loss in Production Foregone Value from Impingement of Forage Species ($2000) | |
|---|---|---|
| | Low | High |
| Black crappie | $463 | $2,326 |
| Bluegill | $52 | $169 |
| Channel catfish | $2,042 | $3,884 |
| Longear sunfish | $394 | $1,272 |
| Muskellunge | $0 | $1 |
| Paddlefish | $3 | $13 |
| Sauger | $285 | $450 |
| Smallmouth bass | $1,508 | $3,769 |
| Striped bass | $1,576 | $2,212 |
| Sunfish spp. | $667 | $2,150 |
| Walleye | $569 | $898 |
| White bass | $1,099 | $2,748 |
| Yellow perch | $0 | $1 |
| Total | $8,659 | $19,891 |

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**Table C4-6: Mean Annual Value of Production Foregone of Selected Fishery Species Resulting from Entrainment of Forage Species at Nine Ohio River Case Study Facilities**

| Species | Annual Loss in Production Foregone Value from Entrainment of Forage Species ($2000) | |
|---|---|---|
| | Low | High |
| Black crappie | $308 | $1,545 |
| Bluegill | $21 | $68 |
| Channel catfish | $5,340 | $10,154 |
| Longear sunfish | $4,041 | $13,035 |
| Paddlefish | $1 | $5 |
| Sauger | $222 | $351 |
| Smallmouth bass | $187,062 | $467,655 |
| Sunfish spp. | $4,656 | $15,019 |
| Walleye | $109,985 | $173,522 |
| White bass | $1,674 | $4,186 |
| Total | $313,310 | $685,538 |

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## C4-4 Nonuse Values

Recreational consumer surplus and commercial impacts are only part of the total losses that the public realizes from I&E impacts on fisheries. Nonuse or passive use impacts arise when individuals value environmental changes apart from any past, present or anticipated future use of the resource in question. Such passive use values have been categorized in several ways in

the economic literature, typically embracing the concepts of existence (stewardship) and bequest (intergenerational equity) motives. Using a "rule of thumb" that nonuse impacts are at least equivalent to 50 percent of the recreational use impact (see Chapter A9 of this document for further discussion), nonuse values of I&E losses at the nine Ohio River case study facilities are estimated to range from $6,200 to $13,600 per for impingement and from $55,600 to $106,300 per for entrainment.

## C4-5 Summary of Mean Annual Economic Value of I&E at Nine Ohio River Case Study Facilities

Table C4-7 summarizes the estimated total annual economic value of I&E losses at the nine Ohio River case study facilities Total impacts range from $27,400 to $435,300 per year for impingement, and from $480,100 to $1,004,300 per year from entrainment.

**Table C4-7: Summary of Baseline Mean Annual I&E Value Losses at Nine Selected Facilities on the Ohio River ($2000)**

| | | Impingement | Entrainment | Total |
|---|---|---|---|---|
| Recreational (Direct Use, Nonmarket) | Low | $12,461 | $111,182 | $123,643 |
| | High | $27,259 | $212,532 | $239,791 |
| Forage (Indirect Use, Nonmarket) | | | | |
| Production Foregone | Low | $8,659 | $313,310 | $321,969 |
| | High | $19,891 | $685,538 | $705,429 |
| Replacement | | $394,396 | $437,061 | $831,457 |
| Nonuse (Passive Use, Nonmarket) | Low | $6,230 | $55,591 | $61,821 |
| | High | $13,630 | $106,266 | $119,896 |
| Total (Rec + Forage + Nonuse)[a] | Low | $27,350 | $480,083 | $507,433 |
| | High | $435,285 | $1,004,336 | $1,439,621 |

[a] In calculating the total low values, the lower of the two forage valuation methods (production foregone and replacement) was used and to calculate the total high values, the higher of two forage valuation methods was used.
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## C4-6 Extrapolation of Baseline Losses to Other Facilities on the Ohio River

Table C4-8 summarizes the estimated baseline economic losses calculated for all in-scope and out-of-scope facilities on the Ohio River by extrapolating the results from the previous analysis. For the analysis, facilities were grouped according to their locations in Ohio River navigational pools, as discussed in Chapter C3. Results for the six pools combined for all in scope and out of scope Ohio River facilities range from $74,700 to $1,388,300 per year for impingement and from $784,400 to $2,443,800 per year for entrainment. Table C4-9 displays results for just the in scope facilities. Values for the in scope facilities are $72,700 to $1,358,700 per year for impingement and $768,400 to $2,393,000 per year for entrainment.

**Table C4-8: Values of Mean Annual Baseline I&E Losses at In and Out of Scope Facilities Grouped as Pools on the Ohio River**

| Pools | Impingement Losses (2000$) | | Entrainment Losses (2000$) | |
|---|---|---|---|---|
| | Low | High | Low | High |
| Hannibal Pool | $494 | $3,749 | $35,020 | $98,309 |
| Markland Pool | $15,830 | $189,246 | $287,318 | $1,384,754 |
| McAlpine Pool | $44,243 | $1,057,334 | $264,468 | $448,605 |
| New Cumberland | $5,669 | $67,480 | $3,173 | $11,187 |
| Pike Island Pool | $3,676 | $29,307 | $5,072 | $28,135 |
| Robert C. Byrd Pool | $4,758 | $41,188 | $189,373 | $472,797 |
| Total | $74,670 | $1,388,305 | $784,424 | $2,443,787 |

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**Table C4-9: Values of Mean Annual Baseline I&E Losses at In Scope Facilities Grouped as Pools on the Ohio River.**

| Pools | Impingement Losses (2000$) | | Entrainment Losses (2000$) | |
|---|---|---|---|---|
| | Low | High | Low | High |
| Hannibal Pool | $423 | $3,215 | $30,029 | $84,300 |
| Markland Pool | $15,602 | $186,525 | $283,187 | $1,364,845 |
| McAlpine Pool | $43,522 | $1,040,096 | $260,157 | $441,292 |
| New Cumberland | $5,380 | $64,037 | $3,011 | $10,616 |
| Pike Island Pool | $3,009 | $23,991 | $4,152 | $23,031 |
| Robert C. Byrd Pool | $4,720 | $40,854 | $187,839 | $468,969 |
| Total | $72,656 | $1,358,719 | $768,376 | $2,393,052 |

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